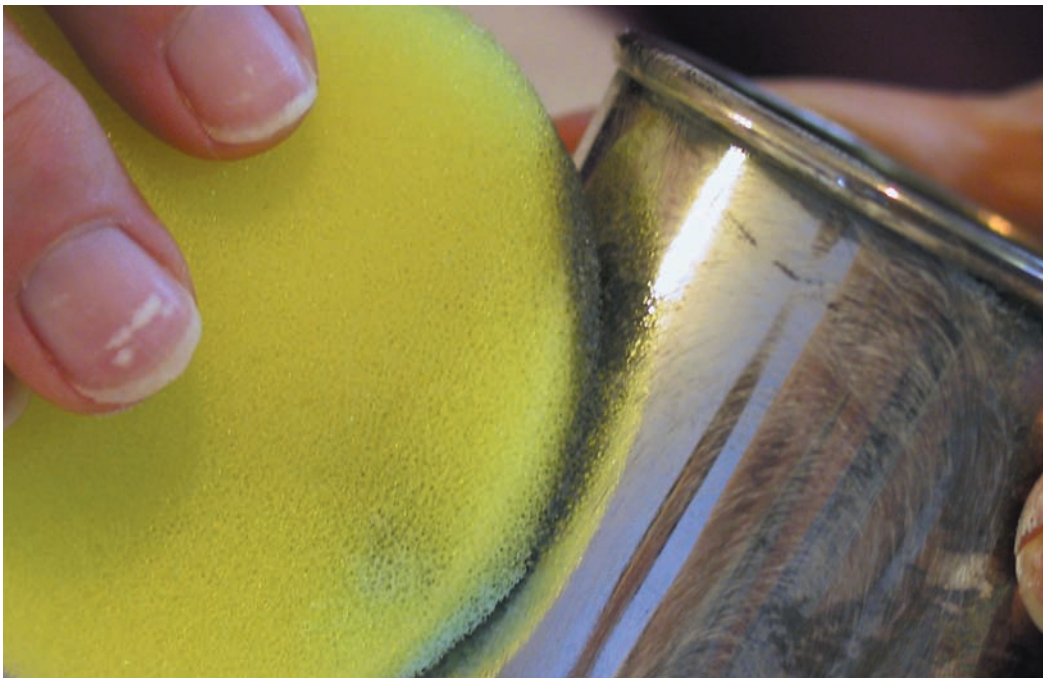
CHAPTER 2

Common Reactions

Getting Ready...

- How can you use chemical reactions to explore your world?
- How do chemical reactions make your life easier?
- Why must you take special care when dealing with certain chemicals?
- How is energy involved in every chemical reaction?



Science Log

List some of the chemical reactions you encounter every day. Try to name one activity you are involved in that does not have a connection to chemicals.

Chemistry happens all around you. Millions of chemical reactions (or chemical changes) occur all the time, even though many of them are invisible to you.

If you could see what happens to the molecules in the flour, sugar, and other ingredients when you bake a cake, you would observe some substances breaking down and others forming. When you develop a roll of film, chemical reactions turn the information stored on the film into pictures of friends and family. When you shampoo, condition, and colour your hair, you are taking advantage of chemical reactions.

Have you ever used silver polish to clean a favourite silver ring, necklace, or cup? All those swirls and pretty decorations make that job a challenging one — unless you know a little chemistry!

In this chapter you will take a closer look at some everyday chemical reactions and begin to appreciate their usefulness to you.

in Our Lives

What You Will Learn

In this chapter you will learn:

- how chemical reactions are useful to you
- how substances change during a chemical reaction
- how to describe different types of chemical reactions
- how to identify the evidence of a chemical reaction
- that energy is absorbed or released by all chemical reactions

Why It Is Important

- You breathe chemicals, eat chemicals, sleep on something made of chemicals, and use chemicals to make your life easier. Knowledge of chemical reactions can help you understand how substances can help or harm you. This knowledge can make you a wiser consumer and provide you with a more comfortable lifestyle.

Skills You Will Use

In this chapter you will:

- carry out procedures and adapt those procedures where needed
- collect and organize information so it is easy to interpret
- demonstrate a knowledge of WHMIS standards by applying proper handling techniques
- identify new questions or problems from what you have learned
- work co-operatively with team members to develop and carry out a plan

Starting Point ACTIVITY

Bottled Sunshine

How do you know when a chemical reaction has occurred? This activity will help you find out.

Safety Precautions

- Clean up the work area and wash your hands thoroughly at the end of the activity.

What You Need

balloon (medium–large size)

Erlenmeyer flask

measuring spoon

20 mL warm water

1 medicine dropper

cresol or phenol red solution

5 g calcium chloride

5 g sodium bicarbonate

What to Do

1. Pour 20 mL of warm water and two droppers of cresol red solution into the Erlenmeyer flask. Add the balloon to the mouth of the flask and gently move the solution around to mix it.
2. Add 5 g of calcium chloride to the solution in the flask. Attach the balloon to the flask and gently mix the solution. Do you notice a change in temperature? Describe the change.
3. Remove the balloon and quickly add 5 g of baking soda. Replace the balloon on the flask and gently mix the solution. Record your observations.

What Did You Discover?

1. Based on your observations, what do you believe is evidence of a chemical change?
2. How can you tell if energy was released?

2.1 Useful Reactions

Figure 2.1 The space shuttle has separate tanks of liquid hydrogen and liquid oxygen. When ignited, these produce a chemical reaction that fuels the shuttle.

Figure 2.2 Ripening bananas go through a chemical reaction. What tells you that a reaction has occurred?

Almost everything you do involves a **chemical reaction**. During a chemical reaction, substances react to produce new substances with different properties from the original substances. Some of these reactions are simple, and some are complex. For example, launching a space shuttle uses complicated technology. A simple chemical reaction makes it possible.

Hydrogen and oxygen combine during a chemical reaction to produce energy and water. Energy powers the space shuttle, and water is a by-product of the reaction.

On the other hand, an everyday occurrence like taking an antacid to treat acid indigestion is based on a different type of chemical reaction. The antacid tablet contains a basic chemical called magnesium hydroxide. Magnesium hydroxide reacts with the hydrochloric acid in your stomach to produce neutral magnesium chloride and water.

How about an even more common chemical change? When you leave a banana on the kitchen counter for a few days, it turns from green to yellow to brown. It is obvious that changes are occurring, as shown in the flow chart that follows.

bananas release natural ripening gas known as ethylene ⇨ ethylene triggers enzyme production ⇨ enzymes speed up chemical reactions

1. enzyme amylase breaks down starches into sugar
2. other enzymes trigger colour change and softening of fruit
3. enzymes break down large molecules into smaller ones that evaporate in the air, providing the banana aroma

READING Check

Describe three everyday chemical reactions.

Try This!

Take two green fruits. Place one in a bag with a ripe banana and the other in a bag alone. Compare the time it takes for each fruit to ripen.

Whitening Whites

Household bleach helps us keep white laundry looking bright and clean. The active component in some bleaches is hydrogen peroxide. Other bleaches contain sodium hypochlorite. Both of these key ingredients contain oxygen. Oxygen is responsible for the reaction that makes a coloured stain colourless.

READING Check

What element gives bleach its whitening power?

Baking Bread

In Chapter 1, you learned about the role of yeast in making bread. Baking bread is a lot like working in a chemistry lab. A baker combines flour, yeast, liquid, salt, and other flavourings in a bowl. The ingredients are shaped into a dough that is left to rise, and then the dough is baked in a hot oven to produce a tasty, nutritious loaf of bread.

Flour is made of cereal grains that release starch and proteins when they are milled. When flour is mixed with water and yeast, enzymes in the yeast break down the starch into glucose. Other enzymes react with some of the glucose molecules to produce carbon dioxide and ethanol, an alcohol. The carbon dioxide then bubbles up through the mixture, causing the dough to rise. Heat causes the pockets of gas in the dough to expand, giving the bread its airy texture. The alcohol burns off in the baking process, leaving behind a delicious flavour.

Figure 2.3 A lot of chemistry goes into every loaf of freshly baked bread.

READING Check

How is chemistry involved in baking bread?

Swimming Pool Scent

Figure 2.4 Chemical reactions involving chlorine keep pools clean and disinfected for swimmers.

DidYouKnow?

The digestion of food requires chemical reactions. Digestive enzymes break down the proteins, carbohydrates, and fats from the foods we eat and convert them to energy for our cells to use. Digestion starts in the mouth, where the enzyme *amylase* in the saliva breaks down starches to simple sugars. In the stomach, the enzyme *protease* speeds up the breakdown of proteins into amino acids. Partially digested foods are then carried to the intestines where an enzyme called *lipase* breaks down fats into glycerol and fatty acids.

You have probably noticed that swimming pools smell distinctly of chlorine. When chlorine is added to water, it produces hypochlorous acid. Hypochlorous acid kills micro-organisms by destroying their cell membranes and inner enzymes.

Cleaners that include chlorine always have warning symbols. That is because chlorine gas is dangerous when inhaled, and it can lead to unconsciousness or even death. Protective rubber gloves and eye protection should be worn when working with chlorine.

READING Check

What substance is produced when chlorine is added to water?

CONDUCT AN

INVESTIGATION 2-A

SKILL CHECK

Initiating and Planning

Performing and Recording

Analyzing and Interpreting

Communication and Teamwork

Identifying Common Gases

Many chemical reactions produce oxygen, hydrogen, and carbon dioxide gases. Knowing how to test for these gases can explain what happened in a particular chemical reaction.

Problem

How do you determine the presence of hydrogen, oxygen, or carbon dioxide gases?

Prediction

Part 1: What will happen to the limewater if carbon dioxide gas is produced?

Part 2: What will happen to the burning splint if hydrogen gas is produced?

Part 3: What will happen to the glowing splint if oxygen gas is produced?

Safety Precautions

- When testing for gases, point the mouth of the test tube away from yourself and other people.
- Clean up the work area and wash your hands thoroughly at the end of the investigation.

Apparatus

3 small test tubes
petri dish
medicine dropper
funnel

Materials

distilled water
vinegar
5 g baking soda
50 mL limewater
20 mL hydrogen peroxide solution
10 grains dry yeast
manganese dioxide
2 wooden splints
matches

Procedure

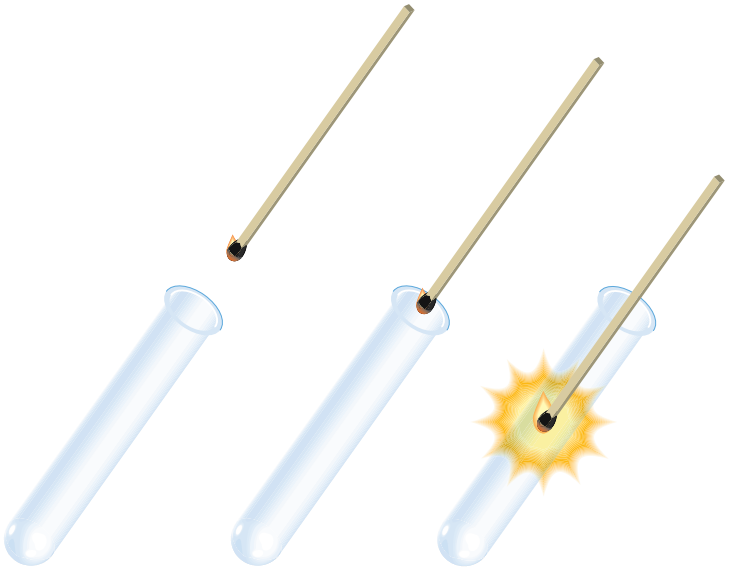
Part 1: Carbon Dioxide Gas

1. Fill a small test tube half full with distilled water. Add some vinegar until the liquid reaches just below the top of the test tube.
2. Fill the bottom of a petri dish half full with distilled water.
3. Add 5 g of baking soda to the test tube. Immediately turn the test tube upside down and place it into the petri dish.
4. Observe what happens inside the test tube. Use your thumb to stopper the test tube and then turn the test tube right side up again.
5. Using a medicine dropper, add a few drops of limewater to the test tube. Limewater turns cloudy in the presence of carbon dioxide gas.

Part 2: Hydrogen Gas

1. Fill a clean test tube half full with distilled water. Add hydrogen peroxide solution until the liquid reaches just below the top of the test tube.
2. Fill the bottom of a clean petri dish half full with distilled water.
3. Add about 10 grains of dry yeast to the test tube. Immediately turn the test tube upside down and place it into the petri dish.
4. Lift up the test tube and stopper it with your thumb.
5. Light a wooden splint.

4. Insert the burning wooden splint into the test tube as shown. If the gas suddenly causes a squeal or pop, this indicates the presence of hydrogen gas.



Test for oxygen gas

Part 3: Oxygen Gas

1. Fill a clean test tube half full with distilled water. Add hydrogen peroxide solution until the liquid reaches just below the top of the test tube.
2. Fill the bottom of a clean petri dish half full with distilled water.
3. Add 1 g of manganese dioxide to the test tube. Immediately turn it upside down and place it into the petri dish.
4. Lift up the test tube and stopper it with your thumb.
5. Light a wooden splint and blow out the flame so the splint is only glowing.
6. Insert the glowing wooden splint into the test tube. If the flame re-ignites, this indicates the presence of oxygen gas.

Analyze

1. Summarize the three tests you used to test for the presence of carbon dioxide, hydrogen, and oxygen gases.
2. How did the results of the three investigations compare to the predictions?

Conclude and Apply

3. Problems may occur in the collection of gases from chemical reactions. What are some?

Extend Your Skills

4. A common product of chemical reactions is water. Suggest a simple test that could be used to test for the presence of water as a result of a chemical reaction.

Try This!

Invert a cold beaker over a burning candle. What happens? Why does this happen? What are the reactants? What are the products?

Figure 2.5 Identify the reactants and products.

Key Terms

chemical reaction

Check Your Understanding

1. Describe three chemical reactions that you read about in this section.
2. List two chemical reactions you did not read about in this section.
3. Liquid bleach is sometimes used as a disinfectant in kitchens. Predict what gas might be formed as the sodium hypochlorite breaks down.
4. Sunlight can break down sodium hypochlorite. Observe the plastic containers used for bleach. Why will you never see a transparent bleach container?
5. Reread the Try This! on page 27. How could you test for the presence of gases resulting from this reaction?

2.2 The Changes That Occur

Figure 2.6 Carefully placed explosives can be used to demolish buildings. This photograph shows the demolition of the Bow Valley Centre (formerly the Calgary General Hospital) in October, 1998.

READING Check

Write definitions for the terms "reactant" and "product."

Chemical reactions occur all around you. Some reactions, like those involved in cooking, require energy. Others, like the demolition of a building, release energy.

In a chemical reaction, the substances you start with are not the same as the substances you end up with. Substances with new properties are formed. This type of change cannot be reversed.

Reactants	→	**Products**
The substances that are there before a chemical reaction.		The substances that form afterwards.

There are several indicators of chemical change. One sign is the release or absorption of energy. Think about what happened during the Starting Point activity at the beginning of this chapter (on page 23). During this activity, you likely felt an increase in temperature. This increase indicated that energy was being released.

In some chemical reactions:
- gases may be given off;
- new solids may be formed; or
- colour changes may occur.

Sometimes odours are also given off.

Combustion and Neutralization

Consider what happens when you light a candle. You bring a lit match or a lighter close to the candle and ignite the wick. You then observe the wick burning, and feel heat and see light being given off.

Candle wax burns in the presence of oxygen to produce carbon dioxide and water. This type of chemical reaction, in which a fuel burns in oxygen, is referred to as a **combustion** reaction. Much of Alberta's industry depends on combustion reactions involving fossil fuels such as oil and natural gas.

Another group of chemical reactions are **neutralization** reactions. During these reactions, an acid is added to a base to produce a compound and water. The pH of the product is more neutral (closer to 7) than the pH of either reactant.

READING Check

List the reactants in combustion reactions and in neutralization reactions.

Many neutralization reactions are involved in cooking. For example, an acid–base reaction between baking soda and an acid such as vinegar (containing acetic acid) or lemon juice (containing citric acid) produces carbon dioxide bubbles that make a cake rise.

In Section 2.1, you learned about a very common neutralization reaction — one that occurs when you take an antacid. You can describe this chemical reaction in one sentence.

Magnesium hydroxide reacts with hydrochloric acid to produce magnesium chloride and water.

You can further simplify this using symbols. The result is known as a word equation.

magnesium hydroxide + hydrochloric acid → magnesium chloride + water

Read the following Did You Know? to learn about some other examples of chemical reactions. Chapter 3 will discuss word equations and other ways to represent chemical reactions.

DidYouKnow?

Although toothpaste ingredients vary by brand, most contain some of the following common ingredients:

- a base such as aluminum hydroxide ($Al(OH)_{3(s)}$) to neutralize the acids in your mouth that can cause cavities
- sodium bicarbonate (baking soda) to help neutralize acids
- fluoride, which bonds to the enamel of your teeth to further protect them from the acids in your mouth
- abrasives, such as calcium carbonate, to help remove stains and plaque
- detergents to create the foaming action that keeps the toothpaste in your mouth, preventing it from running out as you brush
- strong flavourings to cover the taste of detergent
- dyes or colourings to give toothpaste a more pleasing look. For example, titanium dioxide is often used to make some toothpastes look bright white.

Do you know what is in your toothpaste?

Find Out ACTIVITY

An Invisible Gas Made Visible

In this activity, you will look at a common reaction that results in a visible change.

SKILL CHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Safety Precautions

- Clean up the work area and wash your hands thoroughly at the end of the activity.

What You Need

50 mL baking soda
75 mL vinegar
100 mL graduated cylinder
250 mL Erlenmeyer flask
candle
matches
paper towel

What To Do

1. Use the graduated cylinder to measure out 50 mL of baking soda. Place it into the Erlenmeyer flask.
2. Slowly add 75 mL of vinegar to the baking soda in the flask. Cover the jar with paper. Wait about 30 s while the reaction proceeds. In this reaction a gas will be produced, as shown in the figure.
3. Light the candle.
4. Remove the paper from the top of the jar. Carefully pour the gas produced in the flask over the candle flame. Take care not to pour out any of the liquid in the flask.

What Did You Find Out?

1. When have you mixed baking soda and vinegar before? What gas is produced?
2. What happened to the candle flame?
3. Why did this occur?

Internet CONNECT

www.mcgrawhill.ca/links/science.connect2

Use the Internet to investigate the hydrogen fuel cell. The chemical reaction that occurs in the fuel cell is the same as the reaction used to launch a space shuttle. Could it also be useful for powering cars and reducing pollution? Go to the above web site, then to Internet Connects, Unit A, Chapter 2, and then to Hydrogen Fuel Cell.

Key Terms

reactants
products
combustion
neutralization

Check Your Understanding

1. Give three examples of combustion reactions that you encounter in a day. List as many of the reactants and products as you can.
2. Explain one neutralization reaction that occurs in the kitchen.
3. Fishy odours on your hands are caused by a base and can be eliminated with lemon juice. Is this an example of a combustion or a neutralization reaction? Why? What are the reactants?

2.3 Evidence That Change Has Occurred

Chemicals in our environment change constantly. Sometimes we cause these changes. At other times, the changes occur spontaneously without human interference.

During Conduct an Investigation 2–B, you will study many chemical reactions. As you do, look for the evidence that a chemical change has occurred.

Read the contents of the Off the Wall below to learn about various examples of chemical change.

Figure 2.7 Is it magic? No! A chemical change has occurred!

Off the Wall

Figure 2.8 Bacteria produce methane gas in wet locations where oxygen is scarce. Methane gas is often referred to as "marsh gas" because it is present in marshes or bogs. Organic matter, a reactant, undergoes a chemical change that produces methane gas, a product. This chemical reaction also occurs in the intestines of cattle and termites.

Methane gas is a greenhouse gas. In other words, it contributes to the greenhouse effect.

READING Check

Read the Off the Wall, and then explain two examples of chemical change that occur in nature.

Career CONNECT

Water Treatment Plant Operator

Water treatment plant operators monitor and operate the equipment used to purify and disinfect water for human consumption. They may work indoors or outdoors, and are usually employed at water, waste water, or sewage treatment plants in small towns or villages. Depending on the size and location of the treatment plant, some may deal directly with the public to handle water quality complaints and emergencies.

The Northern Alberta Institute of Technology (NAIT) offers a one-year Water and Wastewater Technician certificate program. The educational requirement for the program is a high school diploma. NAIT prefers students who have courses in mathematics, biology, chemistry, and physics, but these are not mandatory. Unit C discusses what can happen if water treatment plant operators do not do their work properly.

Help Wanted
Water Treatment Plant Operator

Job includes:

- taking water samples
- performing routine laboratory tests for chemical content
- adjusting chemical feed rates of disinfectants
- monitoring flow of water through treatment plant
- operating computerized control systems
- keeping daily records of data readings

CONDUCT AN

INVESTIGATION 2-B

SKILL CHECK

Initiating and Planning

Performing and Recording

Analyzing and Interpreting

Communication and Teamwork

Investigating Chemical Reactions

In this investigation you will learn to look for evidence of chemical change.

Problem

What is the evidence that a chemical change has occurred?

Prediction

Predict what evidence of chemical change you might observe for each reaction.

Safety Precautions

- Some of the chemicals you will use in this investigation can burn your skin and clothes. If you spill any on your skin or clothes, flood the affected area immediately with plenty of cool water. Inform your teacher.
- Never touch sodium hydroxide with your bare hands.
- Dispose of all chemicals as the teacher directs.
- Clean up the work area and wash your hands thoroughly at the end of the investigation.

Apparatus

wash bottles
waste containers
electrolysis apparatus
3 (50 mL) beakers
100 mL beaker
test tubes with stoppers
electronic balance
scoopula
graduated cylinder
thermometer
glass stirring rod

Materials

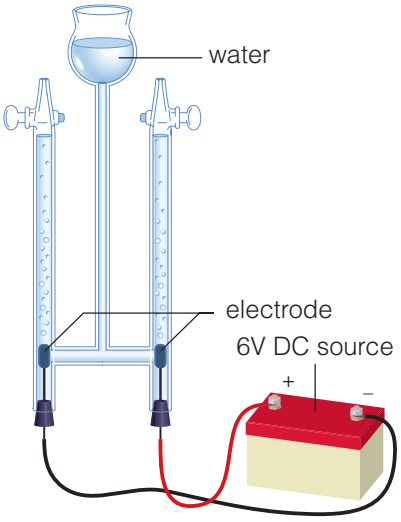
calcium chloride solid
distilled water
sodium carbonate solid
mossy zinc
1.0 mol/L hydrochloric acid solution
0.1 mol/L sodium hydroxide solution
Sani-Flush™ toilet bowl cleaner
0.1 mol/L hydrochloric acid solution
bromothymol blue pH indicator solution
Rolaids™ tablet or Tums™ tablet
paper towelling
manganese dioxide solid
blue litmus paper

Procedure

Your teacher will set up this lab in seven stations, numbered #1 to #7. You will perform each step in the procedure at a different station. As you move from station to station, take care to observe the WHMIS symbols and follow the precautions. Clean up each station before you leave it, so it is ready to be used by the next group. All used chemicals need to be put in the waste containers provided.

1. At each station, record all evidence of chemical change you observe. Also record all reactants. Construct a table similar to the one shown here to record this information. Leave enough space to record the following items for each station:
   - What do the reactants look like?
   - What is the evidence of chemical change?
   - What do the products look like?
2. Station 1: Add 50 mL of tap water to a 100 mL beaker. Use a thermometer to record the initial temperature of the water. Carefully add 3 g of Sani-Flush™ to the water and stir with a glass stirring rod. Describe any evidence of chemical change.

Station Number	Reactants (colours, odours, and whether solid, liquid, or gas)	Evidence of Chemical Change	Products (colours, odours, and whether solid, liquid, or gas)
1			
2			
3			
4			
5			
6			
7			



3. Station 2: The illustration shows an electrolysis apparatus similar to the one set up at this station. Electricity is used to drive this reaction.

4. Station 3:
   (a) To make simulated stomach acid, add 10 mL or 0.1 mol/L hydrochloric acid to a 50 mL beaker. Add 10 drops of bromothymol blue pH indicator solution to the acid and record the initial colour of this solution.

   (b) Crush one Rolaids™ or one Tums™ antacid tablet on a paper towel and carefully add the crushed antacid to the beaker. Stir with a glass stirring rod and record the colour change.

5. Station 4:
   (a) Place 0.16 g of calcium chloride solid into a test tube containing 5 mL of distilled water. Stopper and shake the tube until the solid is dissolved. Observe any temperature change.

   (b) Put 0.15 g of sodium carbonate solid in a second test tube containing 5 mL of distilled water. Stopper the tube and shake to dissolve as before.

   (c) Add the contents of one test tube to the other. Observe the reaction for several minutes.

6. Station 5: Place a small piece of mossy zinc on a watch glass. Add three drops of 1.0 mol/L hydrochloric acid solution. Observe any reaction for several minutes.

7. Station 6: Add 5 mL of 3% hydrogen peroxide ($H_2O_{2(l)}$) to a 50 mL beaker. Use balance to obtain 0.5 g of manganese dioxide ($MnO_{2(s)}$). Carefully sprinkle the manganese dioxide on to the surface of the hydrogen peroxide and record any evidence of a chemical reaction.

8. Station 7:
   (a) Add 1 mL of dilute hydrochloric acid to one 50 mL beaker. Add 1 mL of dilute sodium hydroxide solution (a base) solution to the second beaker.

   (b) Dip one piece of blue litmus paper into the acid and record any colour change. Dip a second piece of blue litmus paper into the sodium hydroxide solution and record any colour change.

Analyze

1. List all the evidence of chemical change you observed in this lab. Include the number of the station(s) where you observed each of these changes.
2. Predict the gas that was released by the chemical reaction at Station 6. Describe a simple test that you could do in order to identify this gas. **Hint**: Check out Conduct an Investigation 2–A on pages 26–27.
3. Name the two gases produced in the reaction at Station 2.

Conclude and Apply

4. Can you imagine observing a colour change that is not caused by a chemical reaction? Name one if possible.
5. Why does a reaction stop? **Hint:** Think back to the reactions at Station 1 and Station 6.

Extend Your Skills

6. It is important that you understand chemical reactions in your environment. Give an example of how recognizing a chemical reaction can help keep you safe.

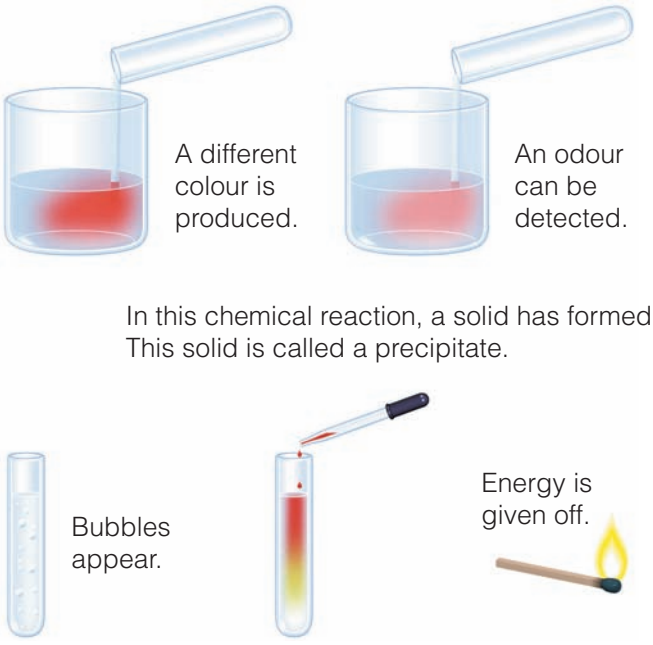

A different colour is produced.
An odour can be detected.
In this chemical reaction, a solid has formed. This solid is called a precipitate.
Bubbles appear.
Energy is given off.

Figure 2.10 Review the five pieces of evidence that indicate a chemical change has occurred.

Evidence of Chemical Change

How can you tell when a chemical change has occurred? Look for some of the following evidence:

- A different colour is produced.
- An odour can be detected.
- Bubbles appear or a gas forms.
- A solid that forms during a chemical reaction is called a **precipitate**.
- Energy is given off in some form — such as light, heat, or sound — or absorbed.

Figure 2.10 shows one example of each.

READING Check

Develop a list of questions you might ask yourself to determine if a chemical change has occurred.

Key Terms

precipitate

Check Your Understanding

1. List the five pieces of evidence that show a chemical reaction has occurred. Give an example of a chemical reaction for each piece of evidence.
2. Here are three word equations to represent chemical reactions. Pick out the one you observed in Investigation 2–B.

   (a) hydrochloric acid reacts with sodium hydroxide to produce sodium chloride and water

   (b) hydrogen peroxide decomposes producing oxygen gas and water

   (c) glucose reacts with oxygen to produce water and oxygen

2.4 Energy and Chemical Reactions

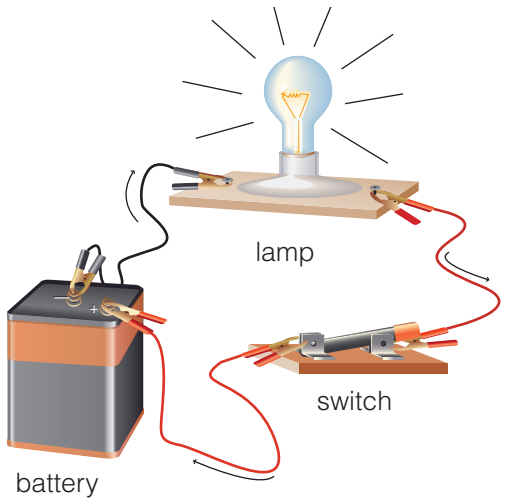


Figure 2.11 Batteries store chemical energy. When a battery is used, a chemical reaction releases electric energy. In this drawing, the electric energy flows through the light bulb, which converts the electric energy to light and heat.

chemical energy → electric energy → light energy and thermal energy

Figure 2.12 Cold packs are often used by athletes to treat injuries. In cold packs, water and ammonium nitrate are held in separate chambers until the pack is needed. When the chambers are broken, the ammonium nitrate dissolves in the water and absorbs heat. This can make the pack as cold as 0ºC. This is an example of an endothermic reaction.

Chemical changes always involve **energy changes**. Some energy changes are obvious and some are unnoticeable. Fireworks are an example of an obvious energy change. When fireworks explode, a huge amount of heat and light are given off.

Rusting is an example of a chemical reaction involving an unnoticeable energy change. Would you believe that heat is released when metal rusts? The amount is so small that it takes very sensitive equipment to detect it.

Knowledge of energy and energy changes is important to society and industry. For example, gasoline is burned in an automobile engine. This chemical reaction results in forward motion and also produces heat. We need to know how much heat is produced so equipment such as a radiator can be designed to cool the engine. This way, the heat produced by the chemical reaction does not damage the engine.

Gasoline working an engine illustrates an **exothermic reaction** because it releases energy into its surroundings. The breakdown (also called the metabolism) of fats and carbohydrates in the human body also releases heat and is exothermic.

Some chemical reactions, like photosynthesis, need to absorb energy in the form of heat or light. Plants need energy from the Sun to produce glucose and oxygen from carbon dioxide and water. Chemical reactions that absorb energy are called **endothermic reactions**.

READING Check

Explain the difference between exothermic and endothermic reactions.

Disc CONNECT

To learn more about exothermic and endothermic reactions and the evidence of chemical change, load the student CD-ROM onto your computer. Launch the **Chemical Reactions** applet and follow the instructions.

DESIGN & DO

INVESTIGATION 2-C

SKILL CHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Hot Packs and Cold Packs

Hot packs are very popular in our cold winters to warm up cold hands and feet. Cold packs are equally useful to relieve a sports injury such as a twisted ankle or bruised knee. Hot packs and cold packs both rely on chemical reactions that involve energy changes in the form of heat.

Challenge

Determine which chemical makes the best hot pack, and which makes the best cold pack. The reaction between the chemical and the water will either absorb or release thermal energy.

Safety Precautions

- Clean up the work area and wash your hands thoroughly at the end of the investigation.

Apparatus

beakers
glass stirring rod
thermometer
waterproof marker

Materials

resealable plastic bags
distilled water
calcium chloride
sodium chloride
sodium acetate
ammonium chloride

Design Criteria

A. The hot packs and cold packs must be made inside resealable plastic bags. **Hint:** Label each plastic bag with the name of the chemical you are using.

B. The only manipulated variable must be the choice of chemical.

C. Data must be collected to show how effective each hot pack and cold pack is.

Plan and Construct

1. With a group, write a procedure for how to compare the chemicals provided. Be specific enough so someone else could duplicate your investigation.
2. Get your teacher's approval, and then perform the investigation.
3. Record all data in a data table.

Evaluate

1. Using a bar graph, compare the starting temperature of each solution to the finishing temperature of each solution.
2. Which chemical produced the most heat? Which absorbed the most heat?
3. Other considerations may influence your final choices for best hot pack and best cold pack. Evaluate the hot and cold packs you have developed according to these criteria.
   - **(a)** cost of chemical
   - **(b)** danger of transporting the chosen substance (**Hint:** Check the WHMIS symbols on the chemicals used.)
   - **(c)** duration of heat or cold production
4. Considering your answers to questions 1 and 2 above, which chemical would you choose for a hot pack? Which chemical would you choose for a cold pack?

Find Out ACTIVITY

A Light Reaction

In this activity, you will investigate an example of an endothermic reaction that releases light energy.

SKILL CHECK

Initiating and Planning

Performing and Recording

Analyzing and Interpreting

Communication and Teamwork

Safety Precautions

- Do not bend activated glow sticks more than once. Excessive bending may break the plastic tube and spill the chemicals inside.
- The activated liquid is non-toxic, but may contain tiny pieces of glass which may cause injury if the light stick is punctured or split open.
- The liquid can permanently stain clothing or furniture and can cause skin or eye irritation.
- Follow your teacher's instructions for disposing of the used glow stick.
- Clean up the work area and wash your hands thoroughly at the end of the activity.

What You Need

thermometer or computer temperature probe
watch
tap water
2 graduated cylinders (100 mL)
glow stick

What to Do

1. Construct a data table for your observations.
2. Read steps 3–6 and then predict what you think will happen to the water temperature in the experimental graduated cylinder.
3. Add 70 mL of tap water to the control graduated cylinder and 70 mL of tap water to the experimental graduated cylinder.
4. Use the thermometer to determine the temperature of the water in both graduated cylinders. Record the temperatures on your data chart.
5. Follow the instructions on the package to activate the glow stick. Place the glow stick in the experimental graduated cylinder.
6. Take and record the temperature of the water in both graduated cylinders at one-minute intervals for at least five minutes.
7. Draw a line graph that includes both sets of data.

What Did You Discover?

1. Do the analysis provided by your teacher.

Check Your Understanding

1. How do exothermic and endothermic reactions differ? How are they similar?
2. Some exothermic reactions can be quite dangerous. Give the reason behind this statement.
3. Fossil fuel combustion reactions involve a fuel such as gasoline or propane. The fuel is combined with oxygen to produce carbon dioxide and water. We often think of these reactions as burning reactions. Are they exothermic or endothermic?

Key Terms

energy changes
exothermic reaction
endothermic reaction

CHAPTER

2 Review

Key Terms

chemical reaction
reactants
products
combustion
neutralization
precipitate
energy changes
exothermic reaction
endothermic reaction

Reviewing Key Terms

If you need to review, the section numbers show where these terms were introduced.

1. In your notebook, match each description in column A with a term in column B.

A	B
(a) chemicals present before a chemical reaction begins	i. combustion (2.2)
(b) a fuel is burned in the presence of oxygen to produce carbon dioxide and water	ii. neutralization (2.2)
(c) when energy is required for a chemical reaction to occur	iii. precipitate (2.3)
(d) a solid that forms in a chemical reaction	iv. exothermic (2.4)
(e) energy, usually thermal, produced in a chemical reaction	v. endothermic (2.4)
(f) chemicals present at the end of a chemical reaction	vi. evidence of chemical reactions (2.2)
(g) bubbles are produced, light is emitted, colour changes occur, energy is released or absorbed	vii. reactants (2.2)
(h) an acid and a base make a compound and water	viii. products (2.2)

Understanding Key Ideas

Section numbers are provided if you need to review.

2. Describe a chemical reaction that you used today. (2.1)

3. If you tested the gas produced in a chemical reaction using a burning splint and heard a popping sound, what gas was produced? (2.1)

4. If you were testing a second gas and found that you could re-ignite a glowing splint in its presence, what is the second gas? (2.1)

5. Use the words "reactants" and "products" to describe a chemical reaction. (2.2)

6. In your notebook, make a table like the one shown here. Complete the table using chemical reactions discussed in this chapter. (2.2)

	Reactants	Products
combustion reaction		
neutralization reaction		

7. List the five pieces of evidence of a chemical change. (2.3)

8. All chemical changes are accompanied by energy changes. Are these always obvious? Explain. (2.4)

9. Think of chemical reactions in your day. (2.4)

(a) Name one that requires energy to proceed.

(b) Name one that releases energy as it occurs.

Developing Skills

10. An electrolysis apparatus demonstrates the breakdown of water into hydrogen and oxygen gases. Combining hydrogen and oxygen gases, which is the opposite reaction, produces water and energy. Explain where this opposite reaction is useful. (2.1)

Problem Solving/Applying

11. When you convert ingredients such as flour, sugar, baking soda, eggs, baking powder, and water into a cake, chemical changes occur. What indicators of chemical reactions can you observe when you bake a cake? (2.2)

12. Liquid bleaches containing sodium hypochlorite ($NaClO_{(l)}$) are often sold in dark plastic containers because sunlight causes the compound to break down into oxygen gas ($O_{2(g)}$) and sodium chloride ($NaCl_{(s)}$). Explain whether you think that the bleach would be effective once the oxygen gas had been released — and why you think this way.(2.1)

13. Imagine you are a research chemist. Why might you want to know whether a reaction would require or absorb energy before you try it in the laboratory? (2.4)

Critical Thinking

14. An industrial chemical process known as the Haber process converts gaseous nitrogen ($N_{2(g)}$) from the air into gaseous ammonia ($NH_{3(g)}$). The ammonia is then used in large quantities to fertilize crops. Look at the chemical formulas. One of the reactants is nitrogen. What is the second reactant? (2.2)

Pause & Reflect

1. Go back to the beginning of the chapter to the Getting Ready questions. How has your thinking changed? How would you answer these questions now that you have investigated the topics in this chapter?
2. Stripping furniture of old paint involves chemical reactions. How would you prepare for such a task, knowing what you have learned in this chapter?